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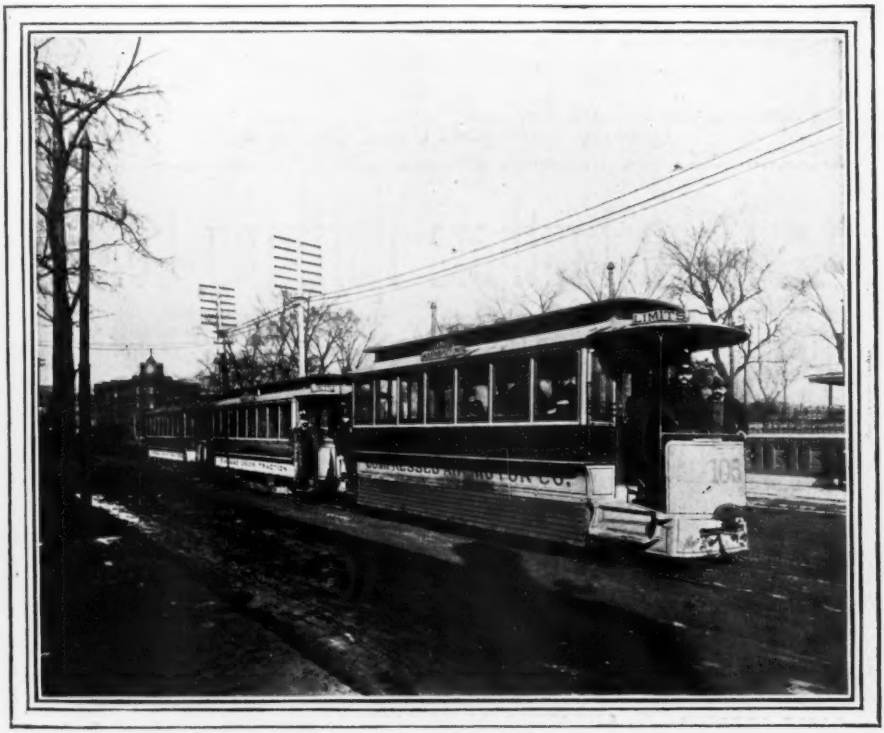

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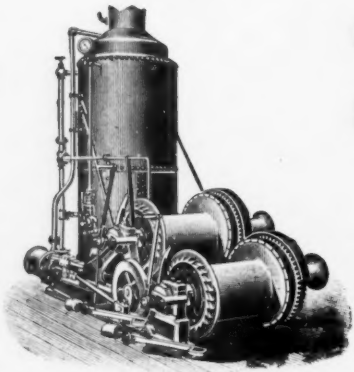

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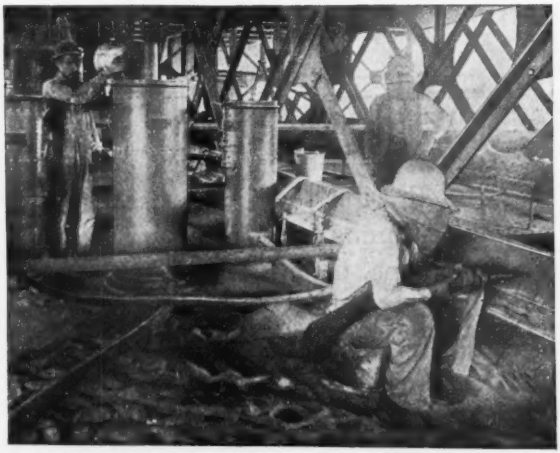

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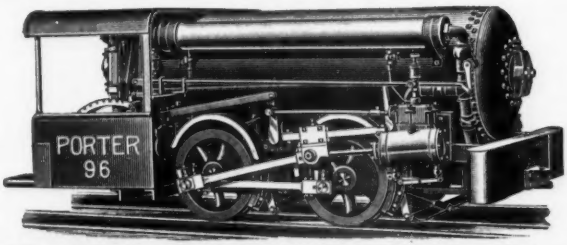

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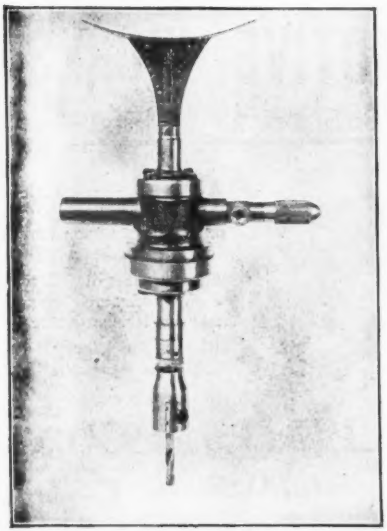

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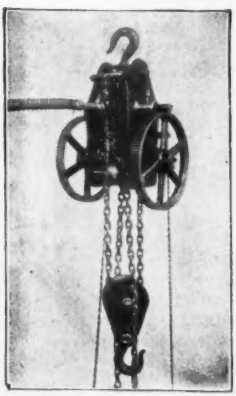

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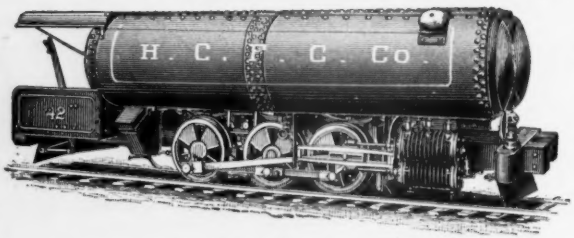

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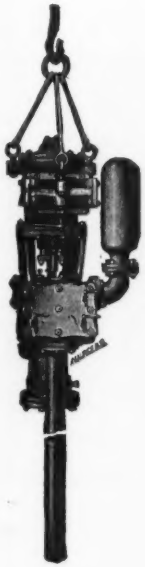

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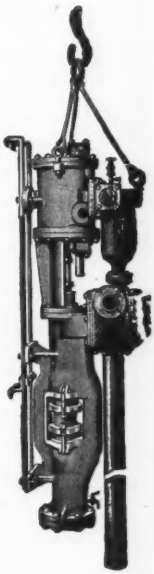

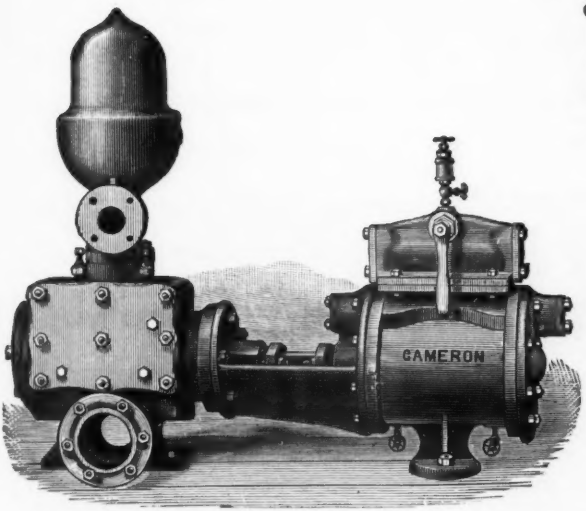

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VOL. V. MAY, 1900. NO. 3.

The air car illustrated on the cover of this issue are those which have been operating for some time past on North Clark Street, Chicago, Ill. The motors are the Hardie type and their service has been very satisfactory. In ordinary weather these cars simply do all that could be expected of them, but in time of storm, when snow and ice cover the tracks, they have proved to be able to cope with the emergency and the system appears to be adapted to all kinds of weather. The Compressed Air Company, 621 Broadway, New York, has issued a pamphlet showing the actual service given by the air cars, and the numbers of passengers carried during very stormy weather.

Mr. H. D. Cooke, president of the Compressed Air Company, has submitted the following statement showing the cost of operating compressed air motors for street car service. For the week ending December 2d, 1899, only 409 cubic feet of free air per mile was used by the air motor cars while carrying passengers, and not including an allowance for occasional trail cars.

"Taking above as a basis of air consumption, and the statement of the cost of compressing air in large volumes as stated by the Ingersoll-Sergeant Compressor Company as being $0.0285 per 1.000 cubic feet compressed to 2,000 lbs. pressure, the cost per car mile (for large installations) 409-1,000 of $0.0285=$0.0117 or in round figures, $1\frac{2}{10}$ cents per car mile.

These figures cover cost of superintendence, labor, coal, waste, oil, interest on cost of power plant and a charge for annual depreciation. Price of coal is charged at $2.90 per ton.

On this basis, and adding charges of wages, conductors and motormen, and labor of charging and repairing motors, the cost of operating per car mile in units of not less than 100 cars would be $0.0756 per car mile.

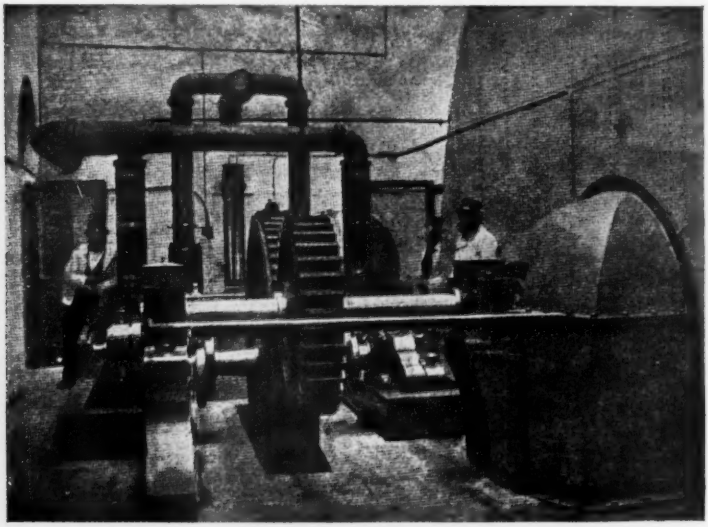
This does not include general expenses, such as interest on, or repairs and maintenance of track and roadbed, or salaries of general officers, damage suits, etc.

The noiseless air brakes, and the starting and stopping of the car with the small lever in the same movement (Hardie system) must reduce chances of accidents and consequent charges to damage account. These figures are based on the results of the present service in Chicago, covering a period of seven months, and also one year's experience on 125th Street, New York. They were gone over, item by item, by practical street railroad men, and are based on actual facts, as stated."

Pneumatic Dispatch

London's Lost Tunnel.

Is there any other city in the wide world where a cast iron tunnel, two and three-quarter miles in length, could lie disused, unknown, lost to the memory of all but a few scientists, for over thirty years, excepting London? I doubt it. For this commercial hub of the universe spins onward at such a rapid rate, that the doings of yesterday are already shrouded in mist, and those of a decade back buried as deeply as if the dust of centuries, not years, lay upon them.



PNEUMATIC ENGINES, HOLBORN STATION.

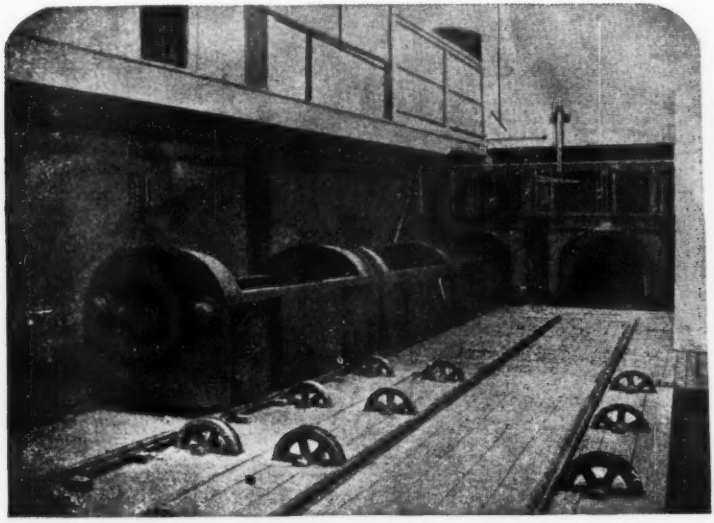
So it is that, under the hurrying feet of millions, even echoing their tramp through the heart of the great city, for long years has lain this almost imperishable testimony to the enterprise, courage, and, alas! misjudgment, of certain of its citizens of the "Sixties." Expert engineers haxe examined the tunnel and proclaimed it to be composed of the very best metal—"cast iron such as is not turned out to-day," to quote the words of a prominent expert—and but little affected by earth, moisture, or disuse, for all its lengthy interment and neglect. Representing as it does the burial of close on £200,000, is it not simply marvellous that no effort until the present has been made to rescue this valuable property from the fungi and huge, whiskered rats, and turn it to some profitable utility? The answer is that the tunnel had been forgotten, simply lost, and the man who "found" it found a gold mine extending from the G.P.O. at St. Martin's-le-Grand to Euston Station. Should the sanguine hopes of the discoverer be realized—and they are based on the reports of the leading authorities—he has "struck" a payable "lead" that is not likely to be "worked out" until flying machines are as ubiquitous and numerous as hansoms in London streets.

Mr. George Threlfall, a consulting engineer, of 50 Fenchurch street, "found" the tunnel, and the story of his discovery is one of surmounting an almost interminable Alps-of-obstacles, and a period

of five years occupied with continual struggle before success crowned his efforts.

The memorable year of 1863 welcomed the abolition of slavery in America, shuddered at the fierce fighting of kin against kin in the Battle of Gettysburg, grieved at the deathbeds of three memorable men —Thackeray, Stonewall Jackson, and General Sir James Outram—and showered sunshine and good wishes on the marriage of H.R.H. the Prince of Wales. It saw also the opening of the Pneumatic Dispatch Company's first section of the tube that, later, starting from Eversholt P.O., N.W., passed down Seymour Street under the Euston Station, along Drummond Street, turning into Hampstead Road, and continuing the length of Tottenham Court Road until New Oxford Street was reached, under which it ran, and under Holborn, plunging deeply down the Viaduct, passing below Farringdon Street, shooting up into Newgate Street, and finally reaching home in the old G.P.O. buildings on the corner nearer Cheapside. The tube, which measures four feet in height by four and a half in width, was erected to carry the mails and postal parcels between the two terminal points and wayside offices by means of pneumatic pressure.

A lad with a pea shooter utilizes pneumatic pressure in propelling his stinging pellets by introducing a force of air behind them; in an inverse manner liquids are imbibed through a straw by sucking the air out, when the interior liquid, thus relieved from pressure, is forced by the weight of the atmosphere on the outside liquid up through the straw. Both these forms of pneumatic pressure were utilized to drive the loaded cars of the Dispatch Company through the tunnel. The car ends fitted the tunnel to within an inch all round. The intervening space was closed so as to be perfectly airtight by a flange of stout indiarubber, which clung tightly to the tube's interior. The air was sucked out from in front of a train of cars by an ingenious mechanical arrangement. Two discs of wrought iron, twenty-one feet in diameter, were screwed on to the sides of an iron wheel having sixteen spokes. Between these two discs, and separated from them, stood a third disc of a corresponding size. Thus this cumbersome wheel, complete, contained

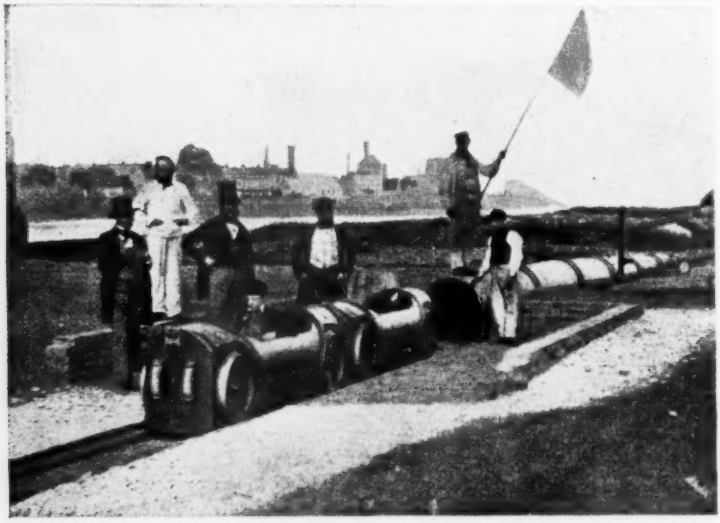


TRAIN OF CARS, HOLBORN STATION.

thirty-two V-shaped cavities. Briefly, it may be said that the revolution of these cavities at a great speed, before huge bell-mouthed pipes, drew by centrifugal force the air out of the tunnel along which the cars, drawn by suction, sped at a rate of thirty-five miles per hour.

The tunnel as it stands to-day is made up of cast iron sections in nine feet lengths and nearly an inch in thickness. Each section was cast in one piece, and in shape resembles a "D" lying on its back, with a groove in the corners along which the rails are laid. At the stations hermetically sealed spring doors excluded the entrance of air, so that when necessary a vacuum could be produced before the departing cars. The addition of an engine to revolve the hollow wheel I have described completed the whole outfit of a scheme that was to revolutionize the prevailing forms of carriage and general motion. In a Times leader of February 10th, 1863, I have found the following: "Between the pneumatic despatch and the subterranean railway the days ought to be fast approaching when the ponderous goods vans which now ply between station and station shall disappear for ever from the streets of London."

Over thirty-six years have passed, and the railway van is to-day more ponderous, ten times more numerous, and a hundred times greater danger to those who use the streets. And yet we boast of our progress! Nevertheless, the journalists of those days revelled in dreams of pneumatic enthusiasm; and schemes, that doubtless then appeared well controlled and feasible, to-day are known to have been of the wildest and most improbable. Listen to the exultation-cum-wailing of the Seven Days' Journal, à propos of the Pneumatic Dispatch Company under date December 13th, 1862: "We are fast making London a marvellous and unequalled city; and if with all our improvements and inventions we could only devise some means for rendering the three millions of dwellers in it safe from the murderous attacks of garotters and burglars, we should have just reason to be proud of our smoke-covered, but unmatched, capital." Well, the smoke is still with us in greater volume than of old; but the many-tailed cat has tamed the murderous thief, and the Pneumatic Dispatch Company has been resurrected and is promised a new life, with electricity for its vital power.



EXPERIMENTING AT BATTERSEA.

Yet another reference to "olden times," and the dead past must give way to the living present. The London Journal, in 1863, printed this piquant paragraph: "Not only have letters and parcels been transmitted through the tube, but we hear also that a lady, whose courage or rashness—we know not which to call it—astonished all spectators, was actually shot the whole length of the tube, crinoline and all, without injury to person or petticoat." Following on this came a multitude of proposals for pneumatic passenger traction. A trial railway was laid at the Crystal Palace, and proved successful. The Waterloo to Whitehall Pneumatic Railway Company was formed. Great Scotland Yard was fixed upon as a site for one terminal station, and adjoining the Waterloo Station in York Road the other. Excavating and tunnelling were commenced. The river was to be crossed in an iron tunnel resting in a dredged channel across its bed. The Illustrated Times of August 17th, 1862, gave a full-sized plate, showing the works in progress, and in accompanying letterpress claimed that, "in its present form, the pneumatic system is simply an adaptation of the process of sailing to railways, the wind being produced by steam power and confined within the limits of a tube." Passengers were to have perfect ventilation, no smoke (excepting tobacco), no steam, no jolting, no vibration, no collisions, and, in fact, none of the disadvantages more or less attendant on any railway line in the kingdom today. Although Messrs. T. Brassey and Co. were the contractors for this ideally perfect railway line, I cannot say where it has disappeared to. Evidently it savored too much of Elysium to be allowed to remain on earthly shores.

Many persons, however, made the journey in the Pneumatic Dispatch Company's cars. The Evening Standard of April 5th, 1863, mentions "Prince Napoleon and his secretary" as being among the passengers, and an illustration on page 623 shows the Holborn Station—which was located in close proximity to the present Royal Music Hall—with a departing car passenger-loaded. For this plate I am indebted to Mr. T. E. Gatehouse, responsible editor of the Electrical Review, Fellow of the Royal Society, Edinburgh, a member of the various Institutions of Engineers, Civil, Mechanical, and Electrical, besides being a well-known amateur violinist. Mr. Gatehouse entered the service of the Pneumatic Dispatch Company in 1869—in days of his fallow youth—and scores of times made the journey through the tube, lying in the fast-flying cars. "The central station was in High Holborn," he states, "and contained the whole of the motive power. Here the cars changed from one set of rails to another, and the time taken in completing the whole journey from end to end was nine minutes. It was always an exhilarating journey, the air being fresh and cool even on the hottest summer days. From Holborn Circus, where the tube dives down a steep declivity under Farringdon street, the speed was about sixty miles an hour, and in the darkness it felt as if I were sliding down a hill feet foremost. The impetus of this rush would carry the car up the incline to Newgate street. To me, who made the trip for the first time, there was something weird and uncanny in being shot through a tube at a high rate of speed, so near the surface of the roadway that the clatter of hoofs and the rumble of vehicles could be distinctly heard, accentuated frequently by the tallow candle or oil lamp being extinguished by the draught. I got so accustomed to the journey that I could tell what corner I was turning, and the street above, precisely, at any moment."

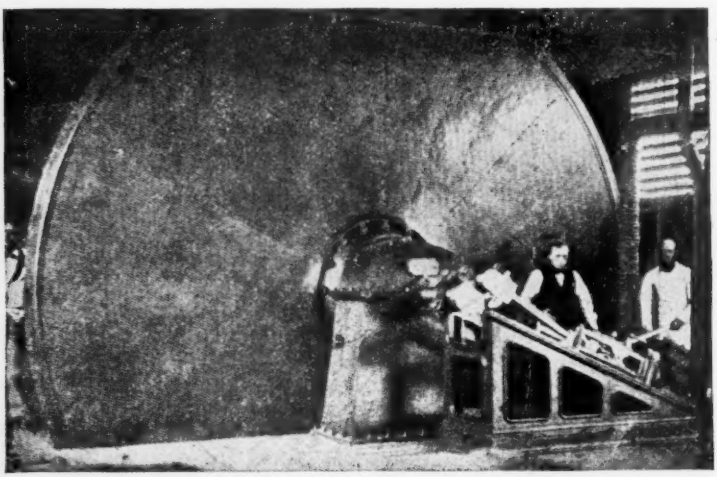
After a period of eight or ten years, the Pneumatic Dispatch Company relinquished operations. At intermittent times only had the line been worked; and quietly, without fuss or flurry, as became the collapse of a gigantic scheme, the end came, and pneumatic propulsion on a wholesale scale received its death-blow in the minds of experts. The insuperable difficulty lay apparently in the impossibility of rendering the tunnel sufficiently air-tight. Leakages of various extents prohibited the creating of a working vacuum, and after the engine power had been increased until it attained six times its original strength, further efforts were considered useless.

The Company had been an extremely powerful one, with rights and privileges guaranteed to it by special Acts of Parliament. Among the directors were the Marquis of Chandos, the Hon. W. Napier, Sir Charles J. H. Rich, Bart., Messrs. W. H. Smith, Thomas Brassey, and others. Mr. John Aird was the contractor of the

line, of which Messrs. T. W. Rammell and J. Latimer Clarke were the joint engineers.

It was in 1895 that Mr. Threlfall first entered the disused tunnel, after struggling and squirming through a heap of débris and lumber in a basement of Euston station, alongside Seymour street. For many yards from the entrance of this terminal there was a trough to allow of the air propelling a car to escape and thus reduce the impact on the receiving buffers. An incautious step upon the rotten wooden platform here precipitated the unwary explorer into three feet of stagnant water, but he nevertheless kept his ardor dry, and after several weeks practically completed his inspection of the whole tunnel (excluding the portion below Holborn Viaduct, which he found full of water), and decided that a fair expenditure would put it in working order for the propelling of cars by electricity.

Having discovered the tunnel and realized its effectiveness, the still more difficult duty devolved on Mr. Threlfall of finding its owners, the original shareholders, or their heirs, together with the necessary plans and papers. It was indeed strange that the mouth-open tunnel, separated from a busy street by merely an iron railing and a few steps, should remain undiscovered even by those of our community whose misdeeds or intentions force them to hide from the inquisitive glare of X 2671's bull's-eye lantern and the clink of his handcuffs. In the troublous times of 1883-84, when misguided wretches were attacking with dynamite bombs London's main thoroughfares and buildings, one shudders to think what the knowledge of the tunnel's existence might have led to on the part of these miscreants. Some dynamite, a line of wire, and a battery spark, and the Nihilist, Anarchist, or Fenian might have sat in safety and ripped a track of death and desolation throughout the metropolis. But there are no apparent signs that the tube was ever the hiding place of any human being. Merely a few skeletons of rats, and presumably cats, judging by the size



PNEUMATIC DISPATCH EXPERIMENTAL WORKS AT BATTERSEA, SHOWING PNEUMATIC DISC AND ENGINE.

—what a Homeric combat of "fighting against odds" do these crumbling bones suggest!—and here and there umbrella-shaped fungi where the water condensation is greatest.

Stranger almost than the loss of the tunnel was the disappearance of its owners and the papers that would tell who they were. After eighteen months' hard search in government offices and the five

parishes through which the tube runs, Mr. Threlfall realized that neither they nor the original contractors had a single plan of the route. It was not until after a wearying system of inquiries half over England and on the Continent that Mrs. Frances Rammell, the widow of the late T. W. Rammell, a famous engineer, was discovered, and, through her remarkable energy, the original plans were eventually brought to light.

To realize the commercial value of the tunnel's discovery and rehabilitation it is necessary to have some slight idea of the extent of mails and parcels passing not only between Euston and the G. P. O., but also between Eversholt P. O., the other local offices en route, and the two main termini. Practically all the heavy post to the north of Great Britain passes through the Euston Station, and the heaviest hour of the day sees a total of eleven tons of postal matter leave the G. P O. for the Northwestern Central Station. At present, vans carrying from one and a half to two tons each, and taking twenty-four minutes under the most favorable circumstances, make the connecting journey. Heavy traffic, fog, greasy pavements, or other drawbacks to vehicular motion, may double the time occupied. The contract time for the delivery of the mails to the various stations is eight miles an hour, and the enforcement of this rate of speed is one of the G. P. O.'s chief difficulties. For a time motor-cars were tried, but without success. The road to Euston is perhaps the most difficult of all to make progress along, and there is no doubt the tunnel, when fitted, will be an enormous convenience to the postal authorities.

A Suggestion.

Compressed air truly a great power is!
And if the tons of air he's spent
In talk in silence were compressed,
Perhaps it would make him President!

—*Detroit Journal.*

Liquid Air

Liquid Air as a Means for the Manufacture of Oxygen.*

By Henry Morton, Ph. D., Sc. D., LL. D.

Readers of the Indicator may remember that in the numbers for April and July of 1899, beginning on pages 113 and 239, there were published two articles by the present writer in which the extravagant claims which had been brought before the public for "Liquid Air" as a source of energy, were discussed and disposed of.

Since that time, until recently, those interested in the promotion of companies which propose to establish a business on the manufacture and use of liquid air as a foundation, have not been prominently before the public.

Quite recently, however, extensive advertisements and circulars have brought the subject into notice along new lines.

Though the langauge of these is largely indefinite or ambiguous, yet it does not seem that the former fallacies have been definitely repeated, though they are in a way hinted at, but the merits of the scheme are now proclaimed in relation to a possible use of the liquid air process as a means for the production of cheap oxygen gas.

Air, as of course all know, is substantially a mixture of four parts of nitrogen with one part of oxygen, and when liquefied in the usual way this proportion is substantially maintained in the liquid. As the liquid evaporates, however, the nitrogen escapes much faster than the oxygen, and thus after a time what is left will be mainly oxygen, the nitrogen having escaped or been driven off, or, as we might say, distilled. If then we pass a stream of liquid air continuously into a vessel in which evaporation is allowed to take place, we will in time find said vessel to be filled with substantially pure oxygen.

If this was all, and no effort was made to utilize the cold of the evaporation of the liquid air such a process would be very costly. Mr. Tripler's figure for the

*Stevens Institute Indicator.

cost of liquid air, it will be remembered, was 20 cents a gallon, and five gallons of "liquid air" would be needed to produce one gallon of oxygen, or in other words, each gallon of liquid oxygen would cost one dollar.

This gallon of liquid oxygen would on expanding to atmospheric temperature and pressure, give about 104 cubic feet, or roughly, each cubic foot of oxygen would cost one cent, or, a thousand cubic feet would cost $10.

It is, of course, obvious that by employing "regenerative processes" by means of which the cold from the escaping nitrogen and also that from the vaporizing oxygen was transferred to the air which was being liquefied, the cost of manufacture could be greatly reduced.

What that reduction would be there are, as yet, I believe, no data for computation, but it would without doubt be considerable, so that it would seem probable that as compared with the chemical methods heretofore in use for the production of oxygen, this new one would be decidedly cheaper.

The question which next presents itself is what shall we do with the cheap oxygen when we get it? This question is more difficult to answer. The present uses for oxygen are very limited, being chiefly for lime lights used in theatres and for stereopticon exhibitions and in some refined processes in metallurgy, such as the working of platinum. The amounts used for these purposes would obviously be quite inadequate to support a large business.

In view of this the "promoters" have naturally turned to the suggestion that oxygen might be used as a substitute for air in ordinary processes of combustion, as under steam boilers, in iron furnaces and the like. In this case the quantities required would be amply great, but here another difficulty presents itself. The cheap oxygen will here encounter the yet cheaper "free" atmosphere as a competitor, and in that connection the cost of storage and transportation would be prohibitory.

For example, it has been suggested that if coal burning under the boiler of a steamship was supplied with oxygen in place of air there would be a saving due to the fact that the heat carried up the funnel by the nitrogen of the air would be retained if oxygen only was fed to the fuel. This saving has been, we think, incorrectly estimated at so high a figure as 40 per cent.

The most conclusive way to test the value of such a suggestion is to reduce it to a concrete case with actually calculated proportions of parts, volumes and weights, as for example, in one of our Atlantic steamers.

To begin with, every ton of such coal as is used on our ocean steamers would require 2½ tons of oxygen for its combustion,* and if this was carried along like the coal supply, the cargo capacity would be fatally reduced, as regards weight, even neglecting the strong steel cylinders in which the gas would need to be stored, and which would weigh much more than the gas.

As regards bulk also, even if the oxygen gas was carried under a pressure of 2,000 pounds to the square inch, each ton of coal would require about 500 cubic feet of compressed gas, and as 2,000 tons is a fair allowance of coal to carry one of our large steamers across the Atlantic, † this would mean that about 1,000,000 cubic feet of compressed gas in cylinders would need to be loaded into such a steamer. This volume of gas alone, not allowing for any lost space between the cylinders, would be more than 10 times that of the "bunker" capacity for the 2,000 tons of coal. ‡

If the gas was not compressed then each ton of coal would require about

*1 lb. of carbon requires 2.66 lbs. oxygen for its combustion, and 1 lb. of hydrogen requires 8 lbs. of oxygen.

English steamer coal contains about 80 per cent. carbon and 5 per cent. hydrogen; American steamer coal, about 75 per cent. carbon and 5 per cent. hydrogen. Average for both coals, say, 77 per cent. carbon and 5 per cent. hydrogen.

Oxygen for pounds of coal—

For carbon	$.77 \times 2.66$	$= 2.05$
For hydrogen	$.05 \times 8$	$= .40$
		2.45

or, say, 2½ lbs. oxygen for combustion of each pound of coal.

†Tons of coal required for steamer across the Atlantic. Table in London Engineering, 1893, Vol. I., p. 469, gives for the Umbria 1,900 tons. The estimate of coal for the Campania from the same table is 2,900 tons. The St. Louis has bunker capacity for 2,500 tons, Engineering, 1895.

‡Space required to store a ton of coal, Kent's Mechanical Engineer's Pocket-Book, p. 170. To store ton of coal, 2,240 lbs. Bituminous coal, 41 to 45 cubic feet. Anthracite coal, 34 to 41 cubic feet.

66,000 cubic feet of gas, or for as much coal as would carry a steamer across the Atlantic, 132,000,000 cubic feet. Now as the capacity of the huge gas-holder which is such a conspicuous object in New York city as seen from the Hudson River, is 3,500,000 cubic feet, it follows that no less than 38 such gas holders, or, if one prefers, balloons of equal capacity would need to be towed along by a steamer to furnish it with a full supply of oxygen. This, it is true, does not allow for the assumed 40 per cent. saving of fuel, and with that included only 22 balloons would be required.

To meet the above, it might be suggested that the oxygen should be manufactured as needed on board of the vessel. This, however, would require machinery comparable in bulk and weight with the engines driving the vessel, and, therefore, this suggestion also fails to relieve the difficulty.

Another practical difficulty which at once suggests itself to any one familiar with the combustion of fuels of any sort in oxygen, is the enormous intensity of the temperature produced. A furnace fed with oxygen in place of air would melt down or burn up in short order, not because a pound of coal would yield a greater quantity of heat if burned with oxygen, but because it would develop this quantity with a more intense combustion and so produce a greater and practically destructive intensity of temperature.

The above simple calculations show how utterly impracticable, not to say absurd, is the suggestion that oxygen might be used with advantage in the furnace of a steamer.

We have selected the case of a steamer from those referred to by the "promoters" of the new oxygen process, as involving data easily secured; but it goes without saying that the conditions with a locomotive or any other traveling motor would be substantially the same, and that even with stationary engines the bulk and mass of the oxygen gas to be handled would render its cost prohibitory by reason of the first cost and operating expense of the machines required to produce and manipulate it.

Traction and Auto-Mobile

The Hardie New Valve Gear.

Mr. Robert Hardie has invented a new valve gear for his compressed air motors, and is having it put on a sixty-foot car now being built at Rome, N. Y., and later it will be applied to the street cars equipped with the Hardie air motors. The object sought in the invention was to obtain an arrangement whereby a cut-off valve could be worked in conjunction with the main valve by one lever. The new gear gives a cut-off (including clearance) at any desired point between 1-10 to nearly ½ stroke. In the position of earliest cut-off there is also the greatest amount of lead, as has been shown by a working model of the gear.

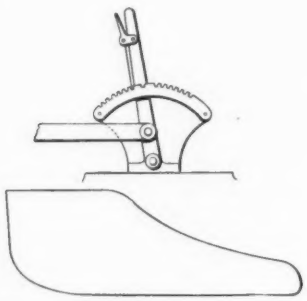
A regular Stephenson link with a fixed cut-off (from 1-10 to 1-5), worked by separate eccentrics, was formerly used on the Hardie cars. While a late cut-off results in a greater consumption of air than an early cut-off, the advantage comes in being able to adopt smaller cylinders. We defer illustrating the new gear until the foreign patents have been granted.

The figures in the accompanying table were calculated from valve and piston movements of the model. The indicator cards for each of the three positions of the reverse lever, as here shown, were drawn from calculations based on the figures obtained from the actual movements of the piston and valves of the model. The expansion curve in each card is between the adiabatic and isothermal.

In the following table are given the openings for every 30 degrees of the main and cut-off valves for three positions of the link, with 3-16 inch for both outside and inside lap of main valve, and 11-16 inch negative lap of cut-off valve. These figures are for cylinders 6½x12 inches, and admission port, ½x⅝ inches. The inside and outside lap being equal, the main valve compression and cut-off take place at the same point. The greatest port openings are taken at the point where cut-off and main valve openings are equal, the cut-off closing while the main valve is opening. There is always ample exhaust opening. The readings in the table were

RESULTS OF DISTRIBUTION OBTAINED BY THE HARDIE VALVE GEAR.

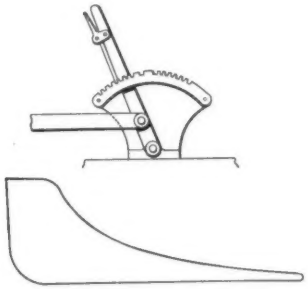
Crank angle, deg.	First position. Main valve (full) travel, 2 in.; cut-off valve travel, 2 in.					
	Cut-off valve opening, in.		Main valve opening, in.		Piston travel, in.	
	Front.	Back.	Front.	Back.	Front.	Back.
0	$1\frac{5}{16}$	$\frac{7}{8}$	$\frac{2}{32}$	$\frac{7}{32}$	.0	.0
30	0	0	$\frac{5}{8}$	$\frac{21}{32}$	.94	.67
60	$-\frac{11}{16}$	$-\frac{23}{32}$	$\frac{3}{4}$	$\frac{7}{8}$	3.39	2.62
90	$-1\frac{3}{32}$	$-1\frac{1}{16}$	$\frac{11}{16}$	$\frac{7}{8}$	6.53	5.48
120	$-\frac{15}{16}$	$-\frac{31}{32}$	$\frac{13}{32}$	$\frac{1}{2}$	9.39	8.62
150	$-\frac{13}{32}$	$-\frac{15}{32}$	$-\frac{1}{32}$	$-\frac{1}{32}$	11.33	11.06
180	$\frac{15}{32}$	$\frac{13}{32}$	$-\frac{9}{16}$	$-\frac{19}{32}$	12.00	12.00



Main cut-off and compression crank angle, 117°.
Lead angle of cranks : front, 18°; back, 18°.
Point of cut-off not including clearance $\frac{1}{2.42}$ of stroke.
Point of cut-off including clearance $\frac{1}{2.29}$ of stroke.
Greatest port opening, $\frac{9}{32}$ in.
Relative travel of main and cut-off valves, $1\frac{5}{8}$ in.

RESULTS OF DISTRIBUTION OBTAINED BY THE HARDIE VALVE GEAR.

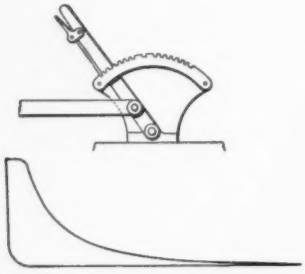
Crank angle, deg.	Second Position. Main valve travel, $1\frac{1}{2}$ in.; cut-off valve travel, $1\frac{11}{16}$ in.					
	Cut-off valve opening, in.		Main valve opening, in.		Piston travel, in.	
	Front.	Back.	Front.	Back.	Front.	Back.
0	1	$1\frac{1}{16}$	$\frac{5}{32}$	$\frac{5}{32}$	.0	.0
30	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{7}{16}$	.94	.67
60	$-\frac{1}{4}$	$-\frac{1}{4}$	$\frac{9}{16}$	$\frac{19}{32}$	3.39	2.62
90	$-\frac{21}{32}$	$-\frac{5}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	6.53	5.48
120	$-\frac{19}{32}$	$-\frac{9}{16}$	$\frac{1}{4}$	$\frac{9}{32}$	9.39	8.62
150	$-\frac{9}{32}$	$-\frac{5}{32}$	$-\frac{9}{64}$	$-\frac{5}{32}$	11.33	11.06
180	$\frac{5}{16}$	$\frac{3}{8}$	$-\frac{1}{2}$	$-\frac{17}{32}$	12.00	12.00



Main cut-off and compression crank angle, 138°.
Lead angle of crank : front, 13°; back, 13°.
Point of cut-off not including clearance $\frac{1}{6.29}$ of stroke.
Point of cut-off including clearance $\frac{1}{5.19}$ of stroke.
Greatest port opening, $\frac{3}{8}$ in.
Relative travel of main and cut-off valves, $2\frac{11}{16}$ in.

RESULTS OF DISTRIBUTION OBTAINED BY THE HARDIE VALVE GEAR.

Crank angle, deg.	Third Position. Main valve travel, 1 in.; cut-off valve travel, 1½ in.					
	Cut-off valve opening, in.		Main valve opening, in.		Piston travel, in.	
	Front.	Back.	Front.	Back.	Front.	Back.
0	$1\frac{1}{16}$	$1\frac{1}{8}$	$\frac{1}{8}$	$\frac{7}{64}$	.0	.0
30	$\frac{21}{32}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{9}{32}$	.34	.67
60	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	3.39	2.62
90	$-\frac{1}{16}$	$-\frac{1}{16}$	$\frac{5}{32}$	$\frac{9}{32}$	6.53	5.48
120	$-\frac{5}{32}$	$-\frac{3}{32}$	$-\frac{1}{16}$	$\frac{1}{32}$	9.39	8.62
150	0	$\frac{3}{32}$	$-\frac{9}{32}$	$-\frac{9}{32}$	11.33	11.06
180	$\frac{7}{32}$	$\frac{5}{16}$	$-\frac{15}{32}$	$-\frac{15}{32}$	12.00	12.00



Main cut-off and compression crank angle, 148°.
Lead angle of crank: front, 12°; back, 12°.
Point of cut-off not including clearance $\frac{1}{14.81}$ of stroke.
Point of cut-off including clearance $\frac{1}{9.54}$ of stroke.
Greatest port opening, $\frac{7}{16}$ in.
Relative travel of main and cut-off valves, $3\frac{5}{8}$ in

taken (for convenience) at equal crank angles, but the valves would be set to cut-off at equal piston movements from each end of the cylinder. The clearance in the cylinder is 4 per cent. The cut-off, including clearance, as noted under each card, means

$$\frac{\text{Piston travel at cut-off} + \text{clearance}}{\text{Stroke of piston} + \text{clearance.}}$$

Tales of Yankee Enchantment.

Tarkus Greenwich Gets Hold of Imitation Liquid Air.

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It is a foolish thing to let a boy have just what he wants. Of course there are some boys who never want anything they ought not to have, but they are so few in number that it is not worth while to take them into account. One of the main reasons that boys have parents is so that they can, with becoming firmness, refuse to let them have the moon and cigars and a night key and other injudicious things desired of young men from babyhood up. But Mr. Greenwich was old enough to be a grandfather when his first son was born, and as grandfathers are notoriously easy with children, he let Aristarchus—for such was the outlandish name that he gave the boy—have anything in reason or out of reason, or in season or out of season, that he expressed a wish for.

Now it was about the time that Aristarchus was 13 that liquid air began to be talked about and after a while it became possible to buy it in small quantities with certain restrictions. A man can't rush into a drug store in great haste and say, "Give us a quart of laudanum or strychnine," and get it, you know. The druggist will have a lot of questions to ask. "Do you intend to take it all yourself or will you share some with your family?" he will say, and after the intending purchaser has satisfied him that he does not want it for himself alone, he lets him have it and takes down his name and address.

So it is with the liquid air shops. The fluid is kept in open bottles—for you can't pen up liquid air safely, and the clerks in charge won't sell a bit until they are satisfied that you are a reliable person with no mischievous proclivities.

Then the clerk makes you sign a receipt for it and after you have paid $150 for a pint, $200 for a quart, $250 for a gallon and $300 for a peck—if my liquid measure is wrong it's because I was absent from school with the measles when the class took up liquid measure—I say after the proper payment has been made, the purchaser is allowed to take the bottle out with many cautions against its improper use.

One day Aristarchus read in a book that liquid air was as cold as 300 degrees below zero. It so happened that the day was insufferably hot. A few lines further he read something like "sick rooms may be cooled by liquid air."

He dropped the book and jumped from the bed where he had been sweltering. "If sick rooms, why not well rooms, and old room in fact? I'll make papa buy me a bottle of this air."

Now, if Aristarchus's father had been a man of the normal age for a parent, that is anywhere between twenty-one and fifty-two, he would have said no sirree when Tarkus (for by that hideous nickname he was known) asked him for a pint bottle of liquid air. But as Mr. Greenwich was 72, he smiled pleasantly and said, "I'll get you some next Saturday when I come up again," and he did.

As soon as he reached the boarding-house, Tarkus ran out to the wagon and said, "Did you get my liquid air?"

"Sh'. Yes I did," said the old gentleman in a low tone. He must have felt that the other men who had come up to spend Sunday would feel nervous if they knew that Tarkus was to have a bottle of unlimited mischief about his clothes.

There were two or three choice spirits known of Tarkus and with the bottle resting securely in his hip pocket he went forth to find them. They were country boys. There were city boys at the boarding-house, but they were fretful, sickly fellows and Tarkus avoided them when he could.

He found Dick Leonard and Billy Mason out behind the Masons' barn, smoking corn silk cigarettes. "Say, fellers, I've got her. Maybe we won't be hot any more."

It was intolerably hot. The thermometer was up in the nineties and the air was damp and muggy. Just the day for a moderate application of liquid air. Tarkus had read the article about Tripler's liquid air to the boys and he supposed that he had a bottle of the real thing.

"What say we do. Just get cool or try coasting?"

"Coatsing!" yelled Billy. "You forget you're hot if you're coasting."

The Masons' pump stood at the brow of a steep hill that ran down in the form of a lane to what they called the "night lot," where the cows were turned after evening milking.

"Now you two boys pump for all you're worth and I'll freeze the water until we have coated the whole hill with a sheet of ice," said Tarkus.

The boys threw away their half-smoked cigarettes and sprang to the pump. The water poured forth in a copious stream and trickled down the hill, but not nearly fast enough to suit the boys, so they overturned the drinking trough, which was full of water. Then Tarkus poured a little of the imitation liquid air out. If it had been the real thing it would have rolled out like smoke and would not have frozen the water, but as it was, the water froze solid, so for the boys' purposes the imitation was better than the real article. Then they filled the trough once more and again upset it, and after a while the whole hill was a glare of ice. Then Billy got his double ripper out of the barn and with loud cries of joy they coasted down hill on ice in midsummer.

If the affair had ended there all would have been well, and old Mr. Greenwich wouldn't have got into trouble, for the ice would have melted in a little while, the boys would have had their fun and no one would have been hurt in any way, but Tarkus, instead of putting the bottle in a safe place, carried it in his hip pocket and at the fifth or six coast he tumbled off the sled and broke the bottle. In an instant the mercury in that vicinity dropped a hundred degrees.

As bad luck would have it, a summer shower had just begun and the rain turned to hail in a twinkling. The boys gazed at each other in silence for a minute, then looked at the fields on either side of the lane. On one side had stood tasseled corn, on the other beans, while at the extreme foot of the hill was an apple orchard. They would have waited to watch the leaves and the corn and fruit blasted in the bitter cold, but they were afraid of getting blasted themselves. They were freezing and were almost too benumbed to get up the hill and into Billy Mason's house.

Mrs. Mason, Billy's mother, was putting up tomato ketchup and the perspiration was rolling from her forehead as she bustled about the hot kitchen, with all the windows open and the torrid sound of the locust fllling the air with its shrilling.

To be confronted by three blue-lipped boys, who with chattering teeth told her that they were freezing to death, was to make her believe that she had gone crazy. And when she felt their poor numb hands, and the coldness of their summer shirts, she was sure of it.

"For the land sakes! Are you bewitched? Where have you been and what has happened?"

Billy explained that the bottle of liquid air had been broken, and then she was as much in the dark as before, for she had never even heard of such a thing as liquid air. But she knew what to do in cases of frost bite and she soon had the boys' hands in basins of cold water and had heated milk for them to drink.

Then she went to the door to see what had happened. The pump was thick with ice and long icicles hung from its lips. The hired man stepped up to it at that minute and the next moment he was coasting on his trousers down the lane and when he picked himself up he began to rub his ears and put for the house as fast as he could.

In violent contrast to this she could see people on the piazza of the boarding-house, fanning themselves vigorously, while in the henyard of the Leonards, the hens were walking about with open beaks, a sure sign of unusual heat.

While she stood gazing, there came a sound of an amazed voice from the cow lane, and then Billy's father, his black beard coated with frost, ran in out of the hail, followed by Snip, the collie, covered from head to foot with ice.

"This beats all," said Mr. Mason, slapping his hands. "A blizzard in August. Where's my Pontiac mittens?"

It was a full hour before the liquid air ceased to act, and by that time the fields in the vicinity of the place where the bottle had broken were covered with a foot of hail.

It didn't take the boys long to recover from their chill and then they put on warm clothes and went out and had an ice-ball fight. And they yelled to some of the city children to come out and play with them, but they shook their heads and

said mamma wouldn't let them. And they probably would have frozen to death.

Of course all the boarders were interested and several got their toes and ears frosted and before the ice was melted, people began to come from all over the country, for the news had been telephoned everywhere and toward night a reporter came out from the city and Tarkus was pointed out to him as the one who had caused the disturbance. Trees coated with ice in August are an unwonted sight and many a snapshot was taken of it all.

Tarkus found that the reporter was a chummy sort of fellow and they became friends at once. "I'm sorry I didn't have a gallon of the stuff, for I could have frosted the whole State just as easy and given you lots of pleasant work writing it up. It's a peachy sight, isn't it?" said the boy.

"Yes," said the reporter, but the joke of it is that it was imitation liquid air."

"Well, I had just as much fun as if it was real. There wasn't any imitation about the cold, anyhow."

And there wasn't any imitation about the sum that Mr. Greenwich had to pay for several barrels of frozen apples and corn and beans, and he now feels that there are some things that he ought to refuse the boy hereafter. And liquid air, imitation or otherwise, heads the list that he has made out.

Air Jets

A Pneumatic Model.

Western Woman's Device for Taking Absolutely Exact Measurements of a Person.

Some time ago a very elaborate apparatus for taking exact measurements of a person, for the use of the tailor or dressmaker, was illustrated, and the device here shown, which is a pneumatic model, completes the sartorial artist's appliances, giving him an exact model on which to fit garments, particularly waists, without requiring the presence of the person for whom the garment is intended. It consists of an inflatable rubber form, conforming, when inflated, approximately to the shape of the body. In using this form, one of a series of different sizes and shapes covers of canvas, or other suitable material, is placed upon it, when in a deflated condition, and over this is fitted a restrainer or lining made according to measurements taken from the person for whom the garment is intended.

PNEUMATIC DRESS MODEL.

When, therefore, the lining, which forms the pattern for the waist, is thus placed on the cover, and the body is inflated by the air pump, the rubber form expands and takes the exact shape of the lining, which can then be used as a model upon which to secure a perfect fit. The canvas cover underneath is used to prevent the elastic material from being pierced by pins or other fastening devices when fitting the pieces for the garment over the lining. Provision has been made by the inventor, a woman, Ella M. Schrader, of Seattle, Wash., to re-enforce the portions of the lining where it is apt to expand unduly. An electric belt, adjustable to any size, which encircles the waist portion of the body, prevents undue expansion at this point. When the average woman's dread of having to stand for a dress fitting is remembered, the boon that Miss Schrader has conferred upon femininity the world over will be readily appreciated.—Louisville Courier-Journal.

On Nov. 13 last Mr. Charles Wood, of Middlesbrough, England, read a paper on "Raising or Lifting Water by Air" be-

fore the Cleveland (Eng.) Institution of Engineers. In this he described the Pohle air lift system of pumping water by "compressed air," as supplied by the Ingersoll-Sergeant Drill Company, New York. This system has become very well known in the United States, and many successful plants are in operation. The simplicity of the method commends itself to all who need water in quantities. It consists of a pipe of suitable diameter being placed in the earth and submerged below the water line 50 per cent. and over. Another pipe of smaller diameter conducts the air to the bottom of the first pipe and the air at suitable pressure is allowed to escape at the base. This lifts the water through the larger pipe to the point of discharge.

Mr. George A. Barden, formerly superintendent of the Standard Pneumatic Tool Company's Works, has been appointed Eastern agent of that company, with headquarters at 619 Washington Life Building, 141 Broadway, New York.

Any one who doubts the extensive use of pneumatic tools will have that doubt dispelled after looking over the "Testimonial" edition of the Chicago Pneumatic Tool Company's catalogue, just issued. It consists of 158 pages filled with expressions of the most flattering kind regarding Boyer tools, and they are written by persons high in position with leading concerns all over the country. In the haze of advertisements of these tools we are informed that they are useful for shipyards, boiler works, engine builders, locomotive factories, railroads, machine shops, and a long list of other places. This new book gives vivid evidence of the earnest work in placing tools and the merit of the tools themselves.

Much interest has been shown in the article published in the March number of "Compressed Air" on the compound Pohle Air Lift for mine drainage. We are informed by Parke & Lacy Company, San Francisco, California, that Mr. E. Le Neuve Foster installed a system of this kind about nine years ago, at the Colorado Central Mine, Georgetown, Col., and it is said to be still in successful operation. The arrangement of the lift is identical with the sketch shown on page 880, March, 1900, except that there are but three lifts of 50 feet, each with a submergence of 50 feet.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz., all communications should be written on one side of the paper only; they should be short and to the point.

East Orange, N. J., April 14, 1900.

"Compressed Air":

In the issue of March there occurs some discussion of atmospheric electricity, the more common phenomena attributable to it, and the formation of hail. This letter may give a better explanation of some of the points of discussion, and be of interest to the readers of "Compressed Air," as containing some ideas on the atmosphere we are compressing, and in explaining what I believe to be an instance of mechanical refrigeration in Nature with air as the agent.

The identity of lightning is well established. Franklin's kite experiment, the disruptive action on trees and buildings of the lightning, the chemical action on the air with formation of nitrogen oxides and ozone, the heat and light of the discharge, and the presence of a static charge in the precipitation of the clouds prove the existence of atmospheric electricity. The trend of observation and experiment show the whole atmosphere is more or less charged, and in a state of electric tension, increasing with the distance from the earth's surface.

The source of production of atmospheric electricity has not been determined. Suppose the sun to be an electrically charged body with reference to the earth, then its inductive action on conductors raised above the surface either in apposition or opposition (mid-day or midnight) will vary with the height, and the potential of a cloud will increase with its elevation. Every one has noticed on a hot summer day the formation of a cloud at a great elevation. The warm, saturated air from a strata close to the earth has pierced the body of the atmosphere above it, raised in a column form and attained

an elevation where the reduced pressure or the pressure of a cold strata has condensed its surplus moisture. The air in raising has expanded, doing work on the surrounding atmosphere and lowering its own temperature adiabatically about 1.6 degree per 300 feet ascension.*

When its dew point is reached a cloud will form. The cloud then becomes a head to the column of warm saturated air from the earth.

Air is capable of carrying static or high potential electricity by a process like convection, and becomes a fair conductor when in a saturated state like this column. Consequently the whole column becomes charged by the electric induction of the sun which produced it. The cloud head being a mass of aqueous air of a relatively high conductivity will acquire a cumulative charge, and any movement of the cooler, dryer air at this elevation will cut off and carry away masses of this charged aqueous air, called cumulus.

This theory explains heat or sheet lightning, the frequency of lightning in the spring and summer, especially during sultry weather, its usual occurrence in connection with showers in the afternoon and evening, and the observed diurnal maxima and minima of atmospheric electric tension.

At sunset, as the inductive action of the sun on the clouds formed or forming declines, due to their being no longer in apposition, we have a quiet or brush discharge to each other, and through the still existing columns of air to the earth.

The thunder shower is an exaggerated convection column or cumulus formation advancing to the eastward and offering a freer path for the ascension and expansion of the warm saturated air near the earth. When precipitation once begins, it promotes condensation nearer the earth in its fall, because the drops of water are not compressed adiabatically again as the air would be, and will, therefore, absorb heat from the ascending air below. Consequently, the cumulus formation lowers and increases in depth. The disturbance in its advance draws up air from strata near the earth for further condensation, and conducts down electricity from the upper strata for disruptive discharge when the cloud formation is within striking distance of the earth. The gust from the storm and preceding the veil of rain is an eddy under the foot of the ascending column of heated air.

The noise accompanying lightning is violent, because the whole energy of the discharge is expended on the air in overcoming its resistance. A large percentage of this energy is changed into heat. In fact, the air path is heated to incandescence, and we can, therefore, understand how the sudden disturbance in the atmosphere due to expansion will produce a wave or vibration of sound. A crackling sound is heard preceding the full note and followed by reverberations, the whole called thunder. The first crackling is not so easily explained; it may be due to an initial brush discharge or divergent arcing from both the earth and cloud; or it may be due to a kind of splash effect in the sound conductivity of air. Like dropping a stone into water. The water splashes out over the surface quickly, and carries the energy of disturbance to a distance, preceding the regular waves which travel to the limits of the watery surface. So, with a sudden disturbance like lightning in air, the sound may be carried in a preliminary crack or splash to a distance in precedence of the regular note of discharge. The continued reverberations of thunder are probably due to the sound proceeding to the ear along different air strata and from different altitudes by paths, each varying in sound conductivity. They may be also due to reflection and deflection of sound from the clouds and the earth.

** Hail occurs as an accompaniment of the more severe of these thunder showers or convection storms, and is distinct from the frozen rain of winter. It falls during the heated hours of the day, usually before the lightning, rarely with and more rarely after, and is accompanied by a rattling noise from the clouds. Hail stones attain a large size, and have a peculiar layered or stratified formation like an onion. All of which has led to attempt, by Volta and others to attribute the production of hail to atmosphereic electricity. But the mechanics of the thunder shower seem to allow only one explanation.

The rising and expanding air is continually cooled by the rain from a higher point, always tending to accelerate its precipitation and give a constantly lowering temperature for a given altitude until we attain temperatures below 32 degrees

*Elementary Meteorology, 1894. Prof. Wm. M. Davis, of Harvard.

**Traité de Physique. A. Ganot.

by expansion within the limits of the cloud formation. The upward motion of the column of convection will carry up and sustain the particles of precipitation until they have attained a certain weight relative to their air resistance. And when the velocity of the convection current is sufficient to bring its precipitation to the altitude of this temperature we have hail formed. Therefore, a severe convection storm is required to produce hail, and the higher the wind velocities the larger the hailstones formed.

The clashing sound noticed during a fall of hail is probably caused by the variation in velocity due to different heights of fall and from the relative air resistances of different sizes and shapes of stones, causing overtaking and striking together in falling.

H. M. Decker.

PATENTS GRANTED MARCH, 1900.

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644,711. — PNEUMATIC WATER-SUPPLY SYSTEM. Frank E. Kinsman, Plainfield, N. J. Filed June 17, 1895.

The combination with the source of water-supply, of a distributing-pipe extending below the level of the water, a water-chamber at the upper end of said pipe, an independently-operating cock closing the exit from said chamber, an air-pipe extending into the distributing-pipe for the purpose described, a cock in the air-pipe, a float in the water-chamber controlling the air-cock, and a snap-action device operating on said float and air-valve, whereby the air-valve is quickly opened and closed at predetermined levels of the water.

645,962.—PNEUMATIC SEPARATOR. Chas. H. Lane, Cleveland, Ohio. Filed Feb. 17, 1899.

646,030.—AIR-COMPRESSOR. James D. McKinnon, Portland, Ore. Filed April 5, 1897.

The combination with a frame, of a plurality of air-compressors mounted thereon and held in a circular line, each compressor having a piston arranged to be separately actuated, a shaft centrally located to said circular line, two plates fixed and spaced apart on the shaft, and a wheel carried between and extending slightly beyond the plates and moving with the same to operate the pistons of the air-compressors independently and successively.

646,031.—AIR-COMPRESSOR. James D. McKinnon, Portland, Ore. Filed March 17, 1899.

In an air-compressor the combination with a frame, an annular series of cylinders mounted therein, inlet and outlet valves for each cylinder, and a plunger in each cylinder, of a shaft mounted centrally in said frame, pitmen connecting the plungers in pairs, each pitman having a slot centrally between its ends for the accommodation of said shaft, an annular series of wheels carried by said shaft, a series of arms, one for each plunger, each arm pivotally connected at one end with the frame and pivotally connected near the other end to one of said pitmen in position to be actuated by said wheels to reciprocate the pitmen and operate the plungers connected therewith.

646,240.—AUTOMATIC AIR-PIPE COUPLING FOR CARS. John W. Spurlock, Ty Ty, Ga. Filed Oct. 17, 1899.

646,318.—COMPRESSED-AIR MOTOR. Benjamin P. Ryder, New York, N. Y., assignor to the Model Marine Motor Company of West Virginia. Filed Nov. 22, 1898.

The combination with a vessel, of a compressed-air motor, comprising a frame, rigidly applied to the bottom of the hold of such vessel, a number of air-compressors mounted upon said frame and moving with it as it moves with the vessel, and a weight suspended within said frame and between the several piston-rods of the said compressors, and adapted to actuate the said piston-rods by direct contact therewith as the frame moves about said weight, substantially as described.

A compressed-air motor, comprising a frame rigidly applied to an object, such as a ship, having a motion of its own and which is imparted to the frame, a number of air-compressors or pumps mounted upon said frame, and moving with it and having converging piston-rods, and a weight or ponderous body suspended within said frame and between the several piston-rods, and actuating said piston-rods by direct contact therewith, all arranged to operate for the purpose described.

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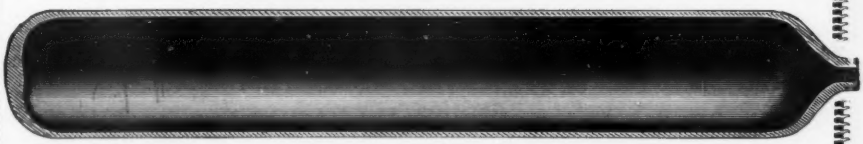

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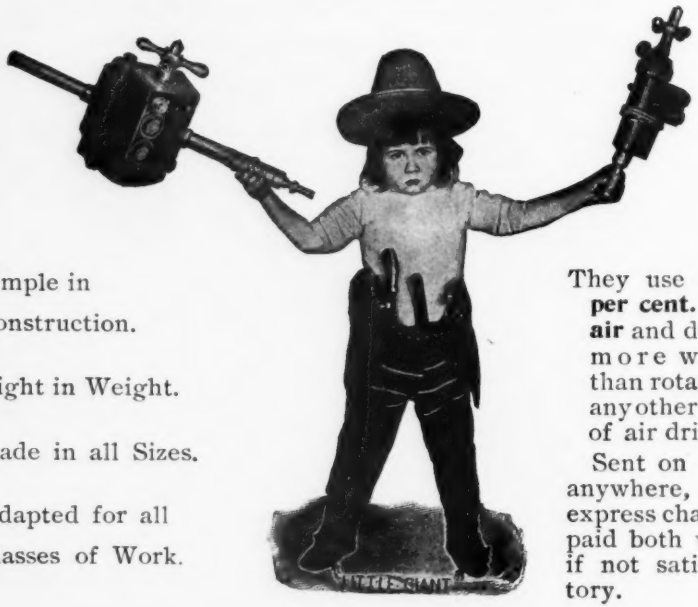

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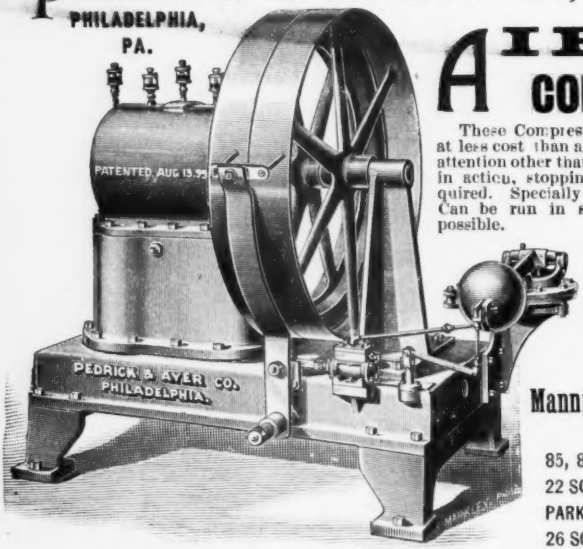

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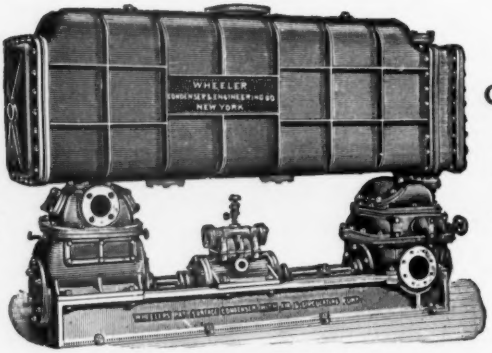

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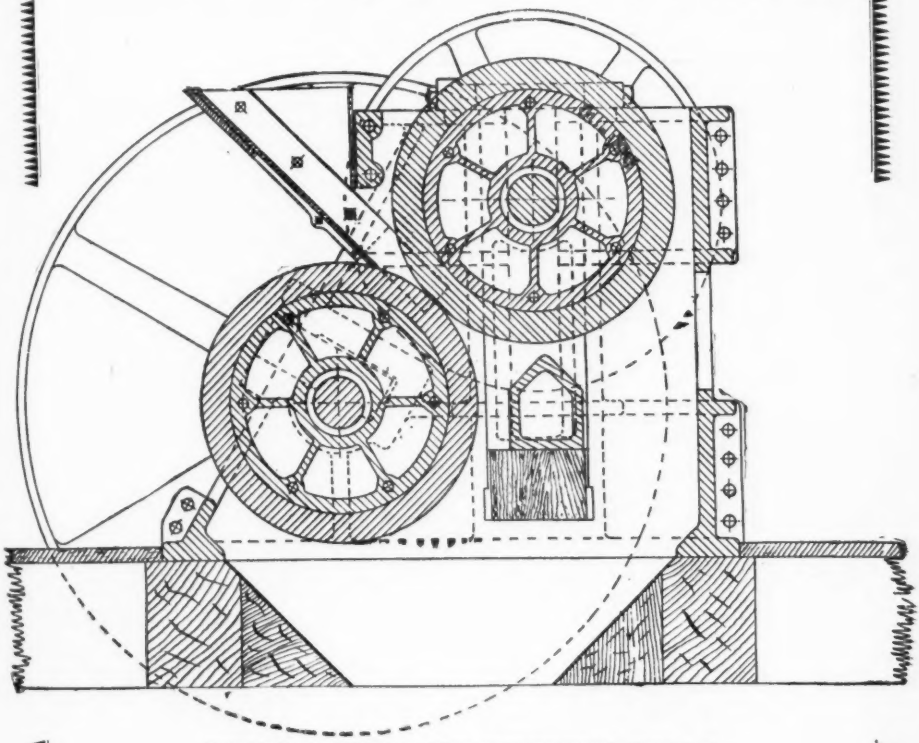

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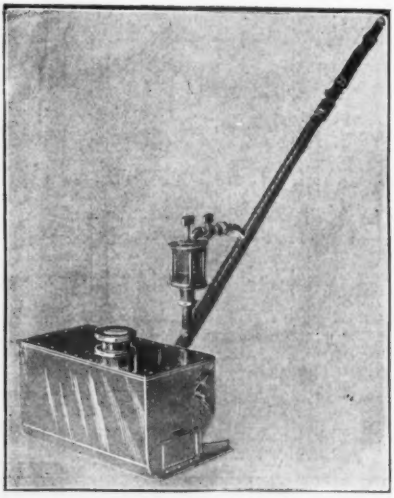

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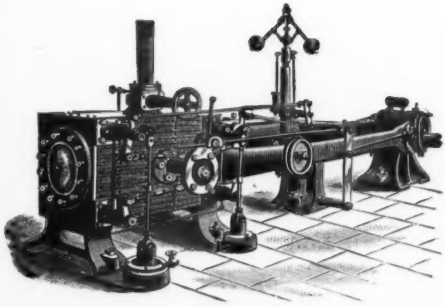

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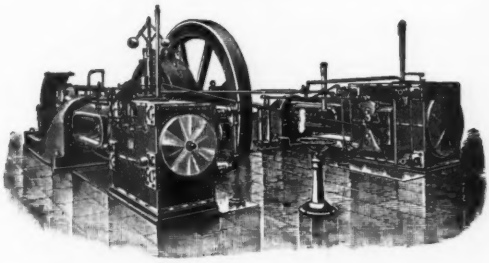

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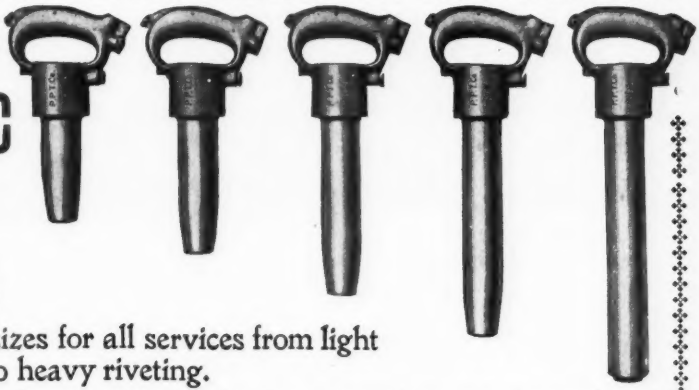

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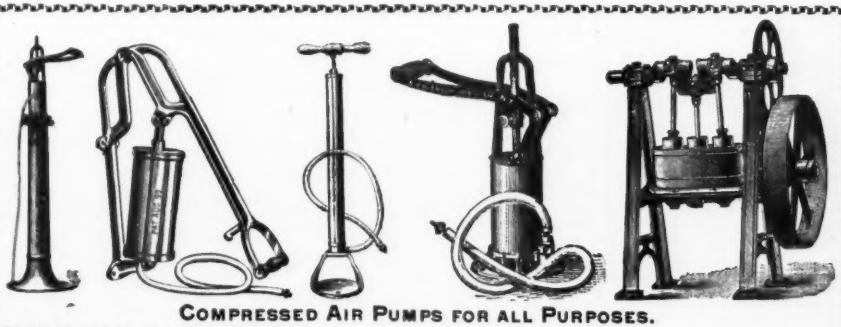

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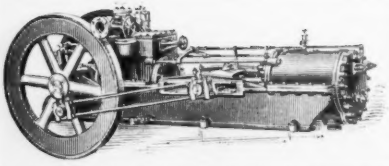

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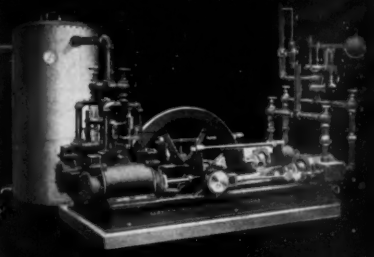

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